Title: A method of producing a superconducting tape

Technical field

This invention relates to a method of producing a High Tc superconducting tape or a High Tc superconducting wire in a metallic sheath.

Background art

A high Tc superconducting wire/tape is usually a composite consisting of a superconducting core and a metallic sheath. Many properties of the wire/tape depend on the metallic sheath materials. Additional layers over the metallic sheath can, however, modify the properties of the wire/tape. For instance

(1) requires a superconducting device such as a motor, a transformer cable or a magnet additional insulating materials between the wires or between the adjacent turns of the winding in order to prevent short circuiting. According to EP 0 786 783 insulating layers have been applied between the superconducting layers formed by bare Bi-2223 tapes. High Tc wires having insulating surface layers could simplify the process of making superconducting devices and the volume of the devices could be reduced.

(2) the mechanical strength of a high Tc superconducting wire/tape depends on the sheath material. An Ag alloy sheathed tape is for instance much stronger than a tape sheathed with pure Ag. However, it is difficult to distinguish the Ag alloy from the pure Ag just by looking. The additional surface layer can be coloured or marked which enable to distinguish between different kinds of wires/tapes. It is common that a tape is annealed in a pan-cake or solenoid form. Asymmetry pre-stress could be built up during the annealing and therefore two sides of a high Tc tape could have

different mechanical properties. It is therefore very important to be able to distinguish between the two different sides during a winding process, for instance by using different colours to distinguish between the two sides of the tape, one colour for the tensile stressed side and another colour for the compressed stressed side. As a result a degrading of the wire/tape could be omitted.

(3) the Ag or Ag alloy sheath is not complete gas tight or liquid tight. Long time exposure in air or long time in contact with with liquid nitrogen could cause a degrading of the high Tc wire/tape. An additional layer could protect the tape from moisture, water, liquid nitrogen or other chemicals which could degrade the superconducting tape.

(4) the additional layer could change the surface friction of the wire/tape. A low friction is for instance needed for winding a superconducting cable.

Such additional layers could be applied by known techniques.

According to US patent specification No. 4 927 985 an insulating layer is applied inside a conductor and the surface of the conductor is metallic. By this construction the insulating layer should be put in the conductor before the mechanical deformation and heat treatment. The materials suitable for the insulating layer are therefore restricted and organic materials cannot be used.

EP0044144 (US4407062) concerns a low Tc superconductor. Low Tc superconductors are totally different from high Tc superconducting materials. The low Tc materials mentioned in EP 0044144 is intermetallic. High Tc superconductors are ceramic. The method for producing the low Tc superconductor is therefore different from the method for producing high Tc superconductors.

Moreover the coating according to EP0044144 is applied before the final heat treatment.

The coating materials are therefore for high temperature use and could for instance be composite of silicate, chalk and China clay.

Sub a1

Without high temperature firing the coating is not stable. It can be simply removed by wiping in hot water and wiping conf. page 10 lines 7-10.

From EP 04449316 A1 it is known to cover a superconducting wire with an organic coat so as to stabilize the superconducting wire against bending.

Brief description of the invention

The object of the invention is to illustrate how the restriction as to the materials could be omitted and according to the invention the additional layer/layers is/are applied after the final annealing. As a result the above-mentioned problems have been solved.

Sub a2

According to the invention the coating is performed after the final heat treatment and the coating materials are typically polymers.

By using a coloured or a marked surface layer one will be able to distinguish between the different wires or different portions of the same wire, for instance to mark one of the sides of the wire/tape.

According to the invention the surface layer could have a low friction and for instance being composed of teflon. Low friction is for instance needed for winding of a superconducting cable.

Brief description of the drawings

In the following the invention will be disclosed in closer detail with reference to the attached figures.

Fig 1 is a sectional view of a high Tc superconducting wire.

Fig 2 is a sectional view of a multi-filamentary tape.

Fig 3 is a sectional view of a bunch of multi-filamentary tapes.

Fig 4 illustrates a continuous coating line for the surface layer over the high Tc superconducting tape.

Best mode for carrying out the invention

Example 1.

In fig. 1 an insulating layer (3) of a thickness of 0,015 mm is applied to a high Tc Bi-2212 wire having a ceramic Bi-2212 core (1) and a metallic sheath (2). The material of the insulating surface layer is PVB and is applied to the wire by a standard dip-coating method at a speed of 5 meters/min using alcohol as a solvent for PVB (5 weight% of PVB). Thereafter the solvent is evaporated and the PVB is cured at a temperature of 250° C in one minute. The surface layer is electrical insulating and can also protect the wire from water and liquid nitrogen.

Example 2.

In Fig. 2 a surface layer of a multilayer structure is applied to a multifilamentary Bi-2223 tape. This tape contains a number of Bi-2223 filaments (1) in a metallic matrix (2). The surface layer contains an insulating layer (3) and an outer low friction layer (4). The insulating layer (3) is applied by using a multifunctional acryllic resin which is cured by means of UV light of 2J/cm^2 by using e. g. a standard Nextrom OFC coating line. A suitable material for the low friction layer is teflon which is applied by a standard dry-powder-coating technique using e.g. a Haugaard powder coating gun. The multilayer surface is insulating and has a low surface friction. A low surface friction can reduce stress in the tape during the winding as well as during the

operation of a superconducting apparatus.

Example 3.

In Fig. 3 the surface layer is applied to a bunch of multifilamentary Bi-2223 tapes. Each of the Bi-2223 tapes is coated with an insulating layer (3) using the method according to example 2. The bunch of the tapes is therefore coated with a low friction (4) layer as described in example 2.

Example 4.

Fig. 4 illustrates a continuous coating line for the surface layer over the high Tc superconducting tape. The finally annealed superconducting tape with metallic surface is sent to a coating apparatus 7 where the surface layer is applied over the tape surface. The coating method can be any traditional coating technique, e.g. dip-coating, spraying, extrusion, painting or dry-powder-coating. The tape with the applied layer is thereafter sent to another apparatus for curing 8. The curing method can be heating or UV curing. After the curing step the coated superconducting tape is ready for use. Of course, more steps can be involved when multilayer structure or colouring is needed.